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Optimization of three different biodiesel productions by transesterification process with various catalysts and alcohols

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ABSTRACT

Straight Vegetable Oil (SVO) is considered as substitutes to diesel but these suffer with the problem of high viscosity. Higher viscosity of SVO is the main reason for their difficult combustion in diesel engines. The objective of this work is to reduce the viscosity of the vegetable oil. Transesterification is the most commonly used and important method to reduce the viscosity of vegetable oil. In this present investigation biodiesel is produced from Ground nut acid oil, sunflower acid oil and fatty acid oil, which is the byproduct of vegetable oil refinery process. During the transesterification process, menthol and ethanol were used with NaOH and KOH as a catalyst. The result shows the higher yield obtained using ethanol with KOH catalyst in all oil. The ethanol produced higher yield of oil is obtained in 620ml 610ml and 630ml for ground nut acid oil, sunflower acid oil and fatty acid oil respectively. The optimum catalyst is 15g of KOH for ground nut acid oil, 14g of KOH for sunflower acid oil and 14g of KOH for fatty acid oil.

KEYWORDS: Biodiesel, Catalyst, Vegetable oil, Transesterification.

INTRODUCTION

Current energy policies are greatly reliant on fossil energy. Fossil fuels are the greatest energy source among all energy resources. The major part of energy requirements in the world is provided thorough fossil fuels such as petroleum, natural gas, oil and coal. Due to resource limitations, it is expected that the rising demand and diminishing supply will affect global fuel prices dramatically [1]. The declining reserve of fossil fuels, and more importantly, the high fuel prices have strongly motivated the search for alternative engine fuels. For diesel engines, a great deal of research effort has been oriented toward using biodiesel as an alternative fuel for land, transport and power generation [2].

In recent years, a search for alternative fossil fuel has been increased due to the environmental problems like global warming and rapidly exhausting reserves of fossil fuel. Biodiesel is a good alternative to fossil fuel because of non-toxic, renewable, biodegradable, aromatic free clean burning fuel that can be used in compression ignitions (diesel) engines with little or no modification [3]. Comprised of monoalkyl esters of long chain fatty acids produced by transesterification of methanol and vegetable oil or animal fats, it has characteristics so similar to conventional diesel. Homogeneous base catalysts (KOH and NaOH) are commonly used in industries for the production of biodiesel because of its high activity and low cost [4].

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These vegetable oil esters are popularly known as biodiesel. One of the potential alternatives to petroleum diesel is the biodiesel which is renewable in nature as it is derived from vegetable oils and fats. In modern times, biodiesel is derived, or has been reported to be producible from many different sources, including vegetable oils, animal fats, used frying oils, and even soapstock [5]. Generally, factors such as geography, climate, and economics determine which vegetable oil is of greatest interest for potential use in biodiesel fuels. Four methods to reduce the high viscosity of vegetable oils to enable their use in common diesel engines without operational problems such as engine deposits have been investigated: blending with petro diesel, pyrolysis, micro emulsification (cosolvent blending), and transesterification. Transesterification is by far the most common method [6]. Only the transesterification reaction Leads to the products commonly known as biodiesel, i.e., alkyl esters of oils and fats.

Methanol is used as the alcohol for producing biodiesel because it is the least expensive alcohol, although other alcohols such as ethanol may yield a biodiesel fuel with better fuel properties. Often the resulting products are also called fatty acid methyl esters (FAME) instead of biodiesel. Although other alcohols can by definition yield biodiesel, many now existing standards are designed in such a fashion that only methyl esters can be used as biodiesel if the standards are observed correctly [7]. The most commonly prepared esters are methyl esters, largely because methanol is the least expensive alcohol, although there are exceptions in some countries. In Brazil, for example, where ethanol is less expensive, ethyl esters are used as fuel. In addition to methanol and ethanol, esters of vegetable oils and animal fats with other low molecular weight alcohols were investigated for potential production and their biodiesel properties. In contrast, ethanol emerges as a great alternative to methanol for the following advantages: mainly produced from biomass; easily metabolized by humans and generates stable fatty acid esters. Additionally, fatty acid ester production with ethanol requires shorter reaction times and smaller alcohol and catalyst amounts when compared to the other possible alcohols, except methanol, used in transesterification processes [8].

A catalyst is a compound that increases the rate of chemical reaction, but not consumed by the reactions, hence allows for the possibility that small amount of catalyst or its activity is lost in the reaction. Catalysts are classified into two groups one for Homogenous catalysts other one Heterogeneous catalysts. A homogeneously catalyzed reaction contains the catalyst in the same phase as at least one of the reactants. Almost invariably the catalyst is dissolved in a liquid phase. An emerging alternative technology is to use smart polymers. These are basically soluble polymers whose solubility can be altered [9]. There can be a change in pH, ionic strength, temperature or even addition of an ion or chemical, the cellulose material is recovered after the reaction by altering the conditions. The transesterification reaction requires low water conditions otherwise the esters produced will be hydrolyzed back. A number of lipase are commercially available and can be used after limited purification [10].

MATERIALS AND METHODS

Ground nut acid oil, sunflower acid oil and fatty acid oil was purchased from SVS & Sons Oil Refinery, Villupuram, Tamilnadu , India. All chemicals such as KOH, NaoH and alcohols such as methanol and ethanol were of AR grade and 99% pure. Ground nut acid oil, sunflower acid oil and fatty acid oil were filtered to remove all insoluble impurities from the oil followed by heating at 100 ºC for 10 min to remove all the moisture. The process is optimized in catalysts and alcohol. In double stage process both catalyst (Alkali based catalysts and Acid based catalyst) were used. In this study Alkali based catalysts (Sodium hydroxide (NaOH) and Potassium hydroxide (KOH)) and Acid based catalysts (Sulphuric acid (H_2So_4)) were used for optimized the yield. The methanol and ethanol are used as the alcohol. All the three oil have higher acid value, so, pretreatment (transesterification) process was applied with using 9ml to 10ml of H2SO4 to reduce the acid value and followed by base catalyst transesterification using NaoH various 1 g to 16g and KOH various 14g to 17g. After the completion of reaction, alcohol-catalyst was separated from upper layer. Next, the transesterified oil is washed with distilled water, until the remains of catalyst were removed and heated to remove water content.

RESULTS AND DISCUSSION

The consolidation of the constant reaction time for best yield on all the three oils of consideration is depicted in table 1. It shows that all oil higher yield in Potassium Hydroxide (KOH) with ethanol.

Table 1: Consolidation of Yield of biodiesel in transesterification at 65°C

Biodiesel	Volume of Ethanol in ml	Weight of KOH in gms	Volume of H_2SO_4 in ml	Volume of yield (Biodiesel) in ml
EEGAO	180	15	10	620
EESAO	180	14	9	610
EEFAO	180	14	11	630

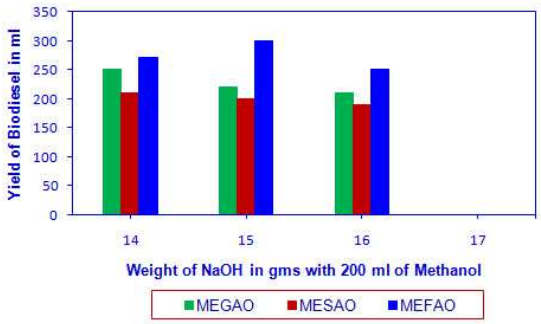

Fig. 1: Biodiesel yield Vs NaOH with Methanol

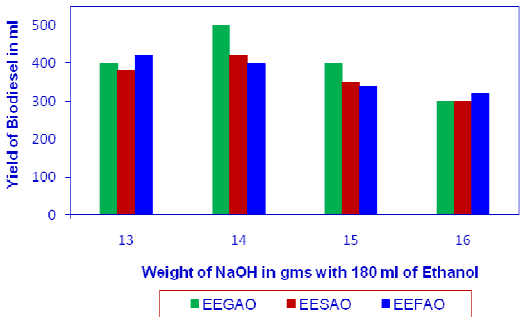

Fig. 2: Biodiesel yield Vs NaOH with Ethanol

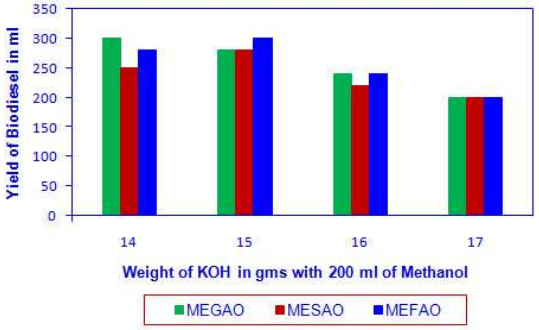

Fig. 3: Biodiesel yield Vs KOH with Methanol

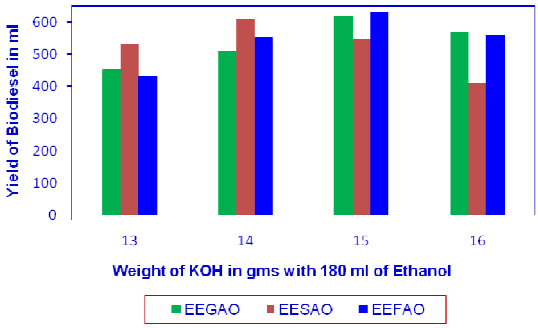

Fig. 4: Biodiesel yield Vs KOH with Ethanol

3.1 Effect of catalyst concentration:

Figure 1 to 4 showed changes in ester yield content with varied catalyst concentration. The catalyst and the alcohol are vigorously mixed with a stirrer in a small reactor. The oil is first charged into the biodiesel reactor and then the mixture of catalyst/alcohol is fed into the oil. Sulfuric acid is used to KOH and NaOH catalyze the reaction. Although the KOH catalysts give high yield of biodiesel, but the reaction rates are slow. The alcohol to oil molar ratio is the main factor influencing the reaction. The steps involve during acid-catalyzed transesterification are: initial protonation of the acid to give an oxonium ion, the oxonium ion and an alcohol undergo an exchange reaction to give the intermediate and this in turn can lose a proton to become an ester [11]. Insufficient amount of sodium hydroxide resulted in incomplete conversion of triglycerides into the esters as indicated from its lower ester content. Large amount of soap was observed in excess amount of sodium hydroxide added experiments. This is because addition of excess alkaline catalyst caused more triglycerides' participation in the saponification reaction with sodium hydroxide, resulting in the production of more amount of soap and reduction of the ester yield [12]. The ester content reached an optimal value when the sodium hydroxide concentration reached 15g, and further increase in catalyst concentration in all the cases, ester production amount decreased. Sodium hydroxide when used in the transesterification process increased the reaction time. Soaps were formed along with biodiesel, during the washing process the soaps stick to the walls of the glass separator. This soap formation reduces the yield of biodiesel. Potassium hydroxide when used as a catalyst gave better results, biodiesel yield increased and the reaction time decreased. The ethanol produced higher yield of oil is obtained in 620ml 610ml and 630ml for ground nut acid oil, sunflower acid oil and fatty acid oil respectively. The optimum catalyst is 15g of KOH for ground nut acid oil, 14g of KOH for sunflower acid oil and 14g of KOH for fatty acid oil.

3.2 Effects of methanol and ethanol:

Figure 1 to 4 shows the two different alcohols such as methanol and ethanol are used in this transesterification process. In this investigation 200 ml of methanol and 180 ml of ethanol are used. Methanol is the simplest alcohol, with one carbon atom; ethanol has two. Sodium hydroxide, also known as "lye," is very corrosive. It also dissolves slowly in methanol. The alcohol usually used is methanol, because it is the cheapest [14]. The process is called methanolysis, when the used alcohol is methanol. This process produces methyl esters from the fatty acids. But while consider the bio diesel yield the ethanol gives higher compare to methanol. The molar ratio of alcohol to vegetable oil is one of the important factors that affect the conversion efficiency as well as production cost of biodiesel. The conversion efficiency is defined as the yield of the process represented in terms of percentage. The presence of water or free fatty acid favors the formation of soap. For this reason the

oils and alcohols have to be essentially anhydrides. The water can be removed by evaporation, before the transesterification [15].

Conclusion:

The study on the biodiesel production process optimization of catalyst, and alcohol are the main factors affecting the production of methyl esters. The optimal values of these parameters for achieving maximum conversion of oil to esters depended on the chemical and physical properties of these oils. The following conclusions are drawn from the study:

Addition of excess catalyst causes more triglycerides' participation in the saponification reaction leading to a marked reduction in the ester yield. Biodiesel production process is incomplete when the methanol amount is less than the optimal value. Operating beyond the optimal value, the ester yield would not be increased but will result in additional cost for methanol recovery. Potassium hydroxide when used as a catalyst gave better results, biodiesel yield increased and the reaction time decreased. The ester content reached an optimal value when the sodium hydroxide concentration reached 15g, and further increase in catalyst concentration in all the cases, ester production amount decreased. Sodium hydroxide when used in the transesterification process increased the reaction time. The ethanol produced higher yield of oil is obtained in 620ml 610ml and 630ml for ground nut acid oil, sunflower acid oil and fatty acid oil respectively. The optimum catalyst is 15g of KOH for ground nut acid oil, 14g of KOH for sunflower acid oil and 14g of KOH for fatty acid oil.

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